Navy Successes and Challenges in Cr6+ Minimization

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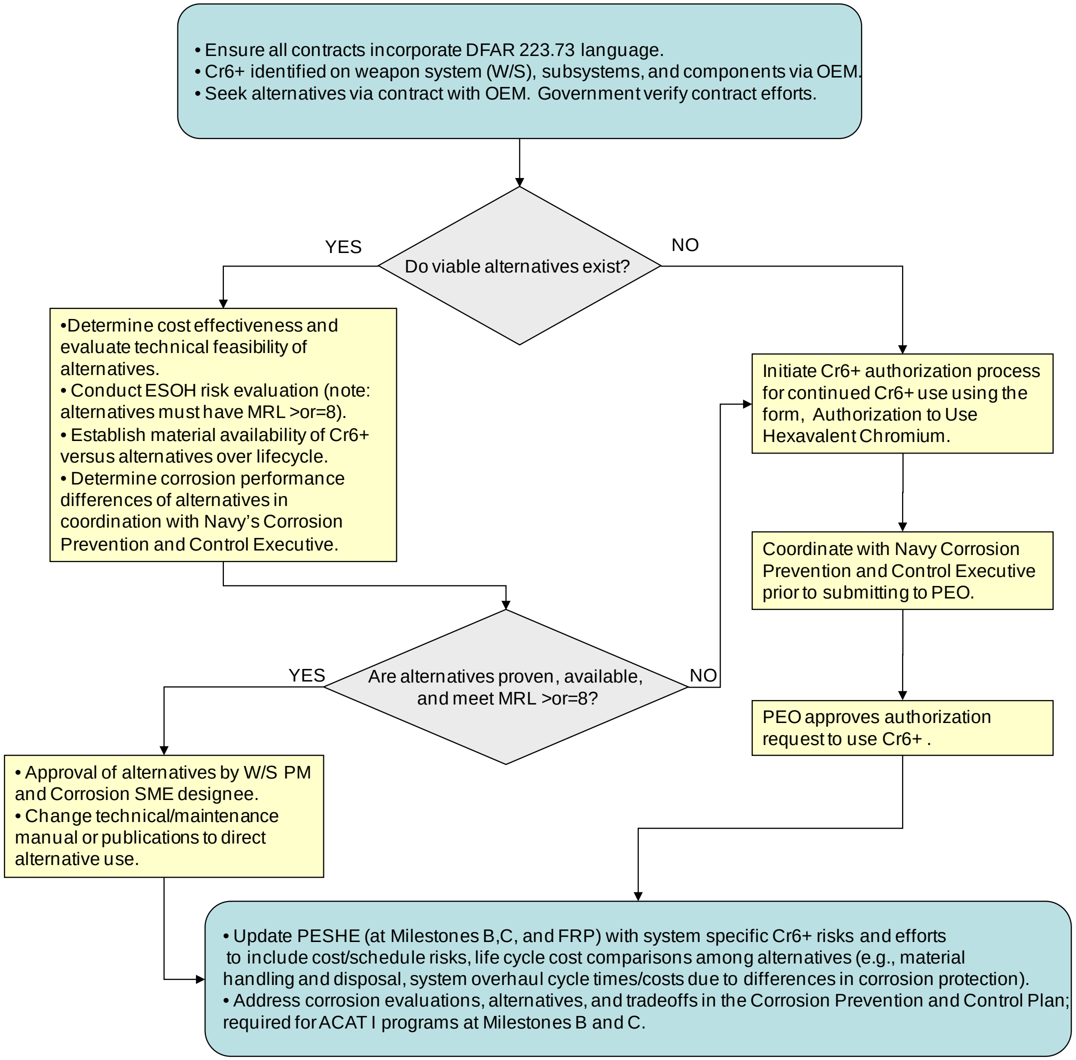
Naval Aviation Enterprise Position on Cr6+ and Path Forward

- **Cr6+ is used in 10 major metal finishing and corrosion protection processes, with many sub-processes**
  - Cost impact is highest for compliance when removing Cr6+ containing coatings, especially sanding at FRCs
  - Application of most materials can be achieved while complying with regulations
- **Alternatives can be implemented during design and production by OEMs and subcontractors and at Navy and contractor facilities which carry out O, I and D-level maintenance.**
- **Many uses include critical engineering applications including adhesive bonding, wear surfaces and corrosion protection on high-strength steels, and protection of critical structure**
- **Compliance with memos and expected DFARs contract language will increase cost of acquisition environmental and corrosion support**
- **Implementation of alternatives is not trivial and requires a risk reduction approach, especially for primers**
- **RDT&E needs to be prioritized and linked to Cr6+ goals**

Cr6+ Waiver Process

- NAVAIR has established a waiver process
- Process in place to meet requirements of new Cr6+ DFARs
- Actions likely to originate with EPAT leads
- Process being expanded to rest of Navy



Implementation Points

- **Design- Implemented at OEMs/Suppliers**
  - New design: finish specifications
  - Easiest to implement, lowest cost, difficult to validate alternatives
- **Production- Implemented at OEM/Suppliers**
  - Engineering Change Proposal (ECP): drawings
  - Medium difficulty to implement, variable cost, validation on fielded assets possible
- **Fielded- Implemented at Gov't and Contractor Facilities**
  - ECP and Local Process Specification modifications; Contract changes; 01-1A-509 and other General Series manual changes
  - Medium difficult to implement for immersion processes, easier for spray and touch up; validation on fielded assets typical

Implementation Progress

- **Use of Chromates in Inorganic Coatings and Processes**
  - Alternatives authorized for
    - Aluminum and magnesium anodizing
    - Hard Chrome Plating
    - Type II, Class 1A conversion coating on aluminum alloys under chromated primer
    - Type II, Class 1A conversion coating on Alumiplate under chromated primer
    - **Sealing of Type IC, IIB, II and III anodize using Type II conversion coatings (TCP)**
  - Alternatives pending authorization
    - **Conversion coating magnesium and titanium**
    - **Sealing of phosphate coatings**
  - Alternatives being assessed in demonstration and validation projects
    - **Type II conversion coating on aluminum alloys with Class N primers**
    - Post treatment of IVD aluminum
    - **Post treatment of IZ-C17+ ZnNi**
    - **Type II conversion coatings on aluminum: Class 3 applications**

Advanced Anodizing using Process Control Technology

(slide courtesy of FRC-SE/R. Prado)

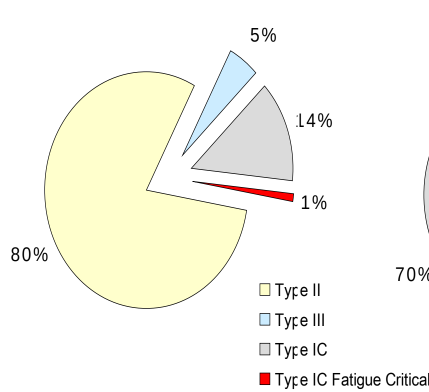
- NESDI N-0086-02: Low HAP Coatings, Solvents and Strippers.
  - Integration of Metalast Process Control technology for producing Type II, IIB & III coatings within one tank system for Depot-Level maintenance
    - Metalast Process Control Technology to include Interface Controller, Process Controller & Bath Additive
    - **TCP as a non Cr+6 post anodize sealer for all coating types.**
  - ROI: 30.7 or Payback Period of 2.1 Yrs

Tank	Process	Volume (gals)
3	Conv Coat	390
8	Conv Coat	600
9	Andz Sealer	1,885
12	Deox	1,885
30	Mag Treat	730
205	Deox	260
212	Andz Sealer	260
	Total	6,010

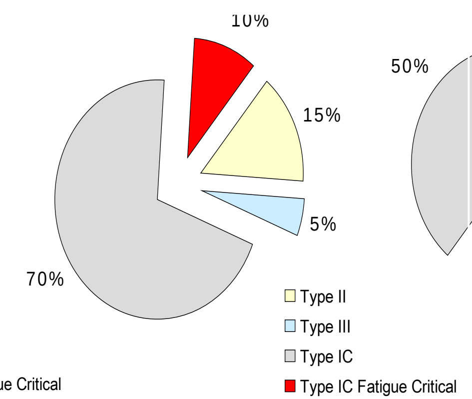
Potential Replacement with TCP

NESDI Project will lead to >35% volume reduction of Cr^{+6} usage in FRC-SE Treatment Shop

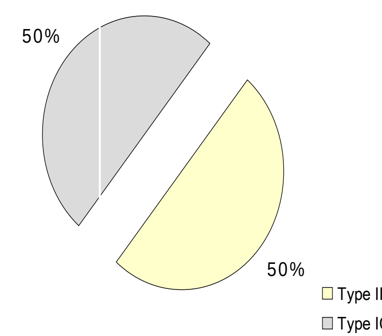
- Capabilities gained:
  - Reduces Operator error and Supervision of Process
  - Improved quality, accuracy and repeatability
  - Reduces defects and rejects
  - Accountability of Work Performed
- Efficiencies achieved:
  - Reduces cycle & throughput times
  - At least 15% more efficient than conventional anodizing
- Environmental benefits achieved:
  - Extends life of bath chemistry/ Reduced Waste
  - Energy savings due to use of aluminum cathodes
  - Allows for consolidation of anodizing processes
  - Elimination of Hexavalent Chromium



FRC-SE (JAX)
Fully Integrated



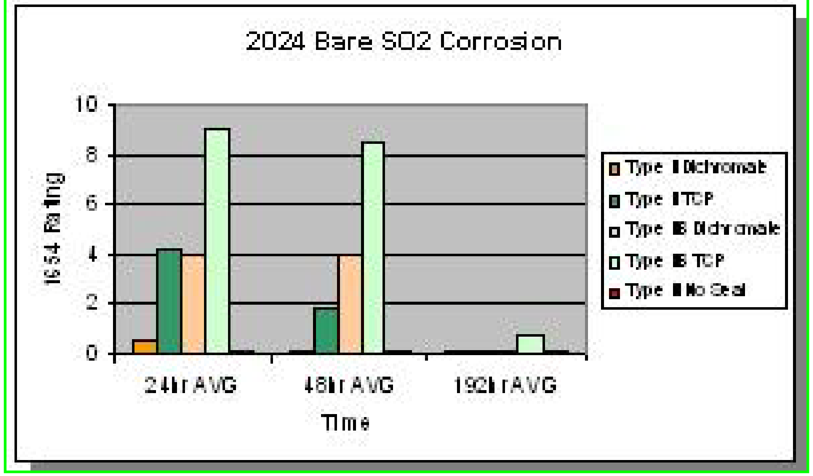
FRC-E (CP)
Fully Integrated



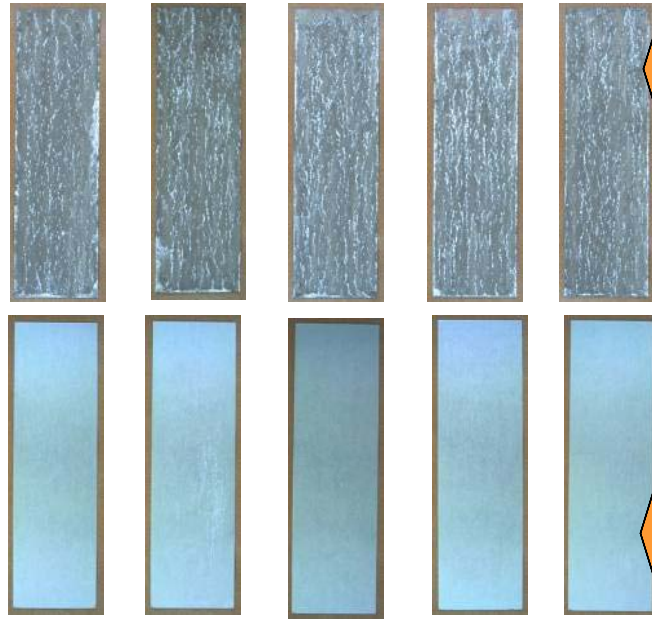
FRC-SW (NI)
Integration in Process

Advanced Anodizing using Process Control Technology

(slide courtesy of FRC-SE/R. Prado)



TCP shows better performance than Dichromate Sealing



Dichromate Seal (5% wt)
Panels A2-BS1C (1 – 5)
15 minute seal @ 203 F

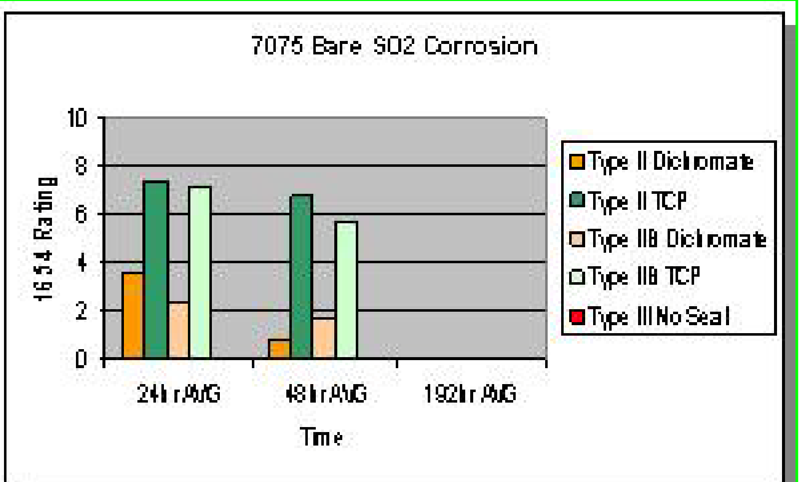
2,033 Hrs NSF

Average Coating Weight:
450 mg/ft2 (~ 2.6 µm)

Current Density used:
8 ASF for 13 min

TCP-HF (1:1)
Panels A2-BS1T (1 – 5)
10 minute seal @ 80 F

Type IIB TCP sealed coupons went well beyond 3,000 hrs before significant pitting corrosion was visible



Dichromate Seal (5% wt)
Panels A2-B2C (1 – 5)
15 minute seal @ 203 F

7,272 Hrs NSF

TCP-HF (1:1)
Panels A2-B2T (1 – 5)
10 minute seal @ 80 F

Average Coating Weight:
2,880 mg/ft2 (~1 2.7 µm)

Current Density used:
12 ASF for 40 min

Implementation Progress

- **Use of Chromates in Organic Coatings and Processes**
  - Alternatives authorized for
    - Priming of support equipment (MIL-DTL-53022)
    - Sealants- various specifications
    - Priming aircraft/components: scuff sand and overcoat applications
  - Alternatives pending authorization
    - None currently
  - Alternatives being assessed in demonstration and validation projects
    - **Primer “direct to metal/conversion coating” in coating systems with chromated or non-chromated conversion coatings**
    - Galvanic primers in total NC systems
  - Alternatives requiring additional research and development
    - Adhesive bond primers
    - Combination of NC primers with other NC finishing options in most applications

NAVAIR Non-Cr6+ Efforts

- **Ongoing**
  - AERMIP- Dem/Val Class N primer/ZVOC topcoat; GSE focused on aluminum
  - ESTCP WP-201010- eCoat primer; alingned with new ESTCP NC Primer project
  - ESTCP WP-201011- self sealing fasteners (non-chromate sealers/primers)
  - ESTCP WP-200906- NC ZVOC coatings (ARL lead); GSE focused on steel
  - SERDP WP-1673- accelerated dynamic corrosion test method (SWRI lead)
  - SERDP WP-1620- scientific understanding of NC inhibitors (Ohio State lead)
  - ESTCP- CoP electroplating
  - DLA- Type II conversion coating touch up pens
  - NAVAIR/NISE- NC primer development and characterization
- **New for FY11**
  - NESDI NC Primer Dem/Val– Supports implementation of qualified Type I and Type II Class N primers at NAVAIR user sites. Includes Type I and II conversion coatings.
  - ESTCP WP-201037- Folds in efforts on e-Coat, Magnesium Rich Primer, Crosslink Primer, and others in development. Will streamline investment in NC primer maturation and dem/val.
  - OSD– Type II, Class 3 Conversion Coatings; electronics requirements
  - NESDI IZ- C17+ zinc-nickel, with non-chromate passivations
  - NAVAIR/NISE- Type II conversion coating dem/val of Surtec 650V

NAVAIR Non-Chromate Coatings Goal

Identify, test, validate and implement non-chromate primers and surface preparations which are as broad in capabilities and performance as current chromated primers and surface preparations.

- **Performance across multiple alloys/substrates, with and without topcoats per MIL-PRF-85285 and TT-P-2760; in combination with specialty coatings**
- **Across all exposure conditions for all the materials currently protected by Class C materials.**
- **Galvanic Corrosion Protection – faying surfaces, dissimilar materials interfaces, wet installation of fasteners and bushings, SCC, exfoliation, etc.**
- **Surface Prep/Primer Compatibility –**
  - Type I and Type II conversion coatings per MIL-DTL-81706/MIL-DTL-5541
  - Type I, IC, II, or IIB anodized aluminum per MIL-A-8625
  - Sacrificial coatings (such as IVD-Al, Cd, Zn-Ni, etc.)
  - Fe alloys, other conversion coated or anodized light metals such as Ti and Mg and composite substrates
  - Adhesion, filiform, humidity, and fluid resistance properties

NAVAIR Primer Issues

- **“Silver” Standard – MIL-DTL-5541 Type II/MIL-PRF-23377 Class N**
  - Most applications covered – 95+% solution (Type I and Type II)
  - Next Gen Primers needed for Type I and II to meet/exceed chromated coating system performance: just about all Class N work is on Type I products
  - Robustness is Key – Most robust surface preparations + most robust organic coatings = Most robust coating systems
  - Misconception regarding VOCs of the two primer specs – both are 340 g/L
- **Resin Properties often overlooked –**
  - Inhibitor is not the only functional component, adhesion and barrier properties controlled by resin system
  - Impacts pigment loading and inhibitor release function
  - 23377: High-solids “solvent-borne”- superior resin system for total protection
  - 85582: “water-borne”- better application characteristics
  - Effect more pronounced in Class N primers, but diminishing as Class N primers are improving
    - Rely more on surface preparation performance

NC Primer Thrusts

- **Develop documented process to test, demonstrate, validate and implement NC primers (and other NC coatings)**
  - NC Coatings systems “engineering circular” completed
  - Pending completion
- **NC primer qualification and authorization**
  - MIL-PRF-23377 Class N; MIL-PRF-85582 Class N; TT-P-2760 Class N (no Class Ns qualified)
    - Continue to assess new NC primers as they become available
  - Class Ns only authorized currently for over-coating Class C primer
  - Implementation “direct to metal” on case-by-case basis in low risk applications
    - Trainers: “T-XX”- outer moldline repainting; in combination with new Type IV topcoats
    - ~25% of a/c in NAVAIR inventory

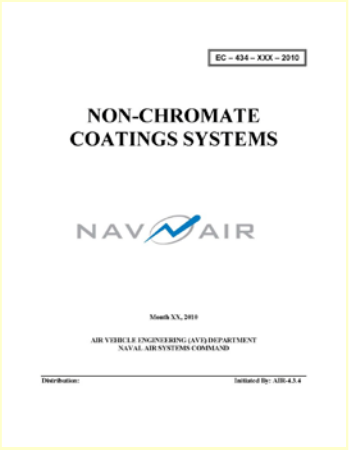
NC Primer Thrusts

- **NC Primer validation**
  - Validation on legacy aircraft (primer applied during scheduled depot maintenance)
    - Field testing: current, low risk
      - Deft 02GN084- exterior of fleet E-2 Hawkeyes (4), w/Type I conversion coating (North Island)
    - Field testing: planned, low risk (NESDI funding)
      - Hentzen 17176 KEP Type II on H-46s with Type II conversion coating (Cherry Point)
      - Hentzen 17176 KEP Type II on H-46, H-53 and AV-8B composite surfaces (Cherry Point)
      - E-2 follow on: F/A-18 exterior with leading Type II primer at time of painting (w/Type I conversion coating)
      - C-2 exterior with Type I NC primer and Type II NC conversion coating
    - Field testing: planned, medium risk (NESDI funding)
      - E-2/C-2 interiors and components with leading Type I primer at time of painting
    - Field testing: planned, low to medium risk (program funding)
      - H-60R/S Seahawks
  - Validation on new aircraft (primer applied during production)
    - Deft 02GN098 on F-35B and F-35C test aircraft
      - No ship environment until ~2013
    - Deft 02GN084 on MQ-8B Firescout test/LRIP aircraft
      - a/c already operating from ship during testing
  - Expanded laboratory validation (NESDI and ESTCP efforts)
    - Galvanic interfaces
    - Stress corrosion cracking and corrosion fatigue
    - Additional substrates: anodized aluminum, magnesium, high-strength steel with cadmium, aluminum and zinc-nickel, composites

NC Primer Thrusts

- **NC Primer development and validation (new ESTCP NC primer project)- NAVAIR lead, joint service effort**
  - Task I: Assess maturity of current products (coating performance and process), commercial and developmental. Assess application potential for each candidate relative to service needs (including OEMs/subs)
    - Task 1A: Develop comprehensive test methods and guidelines to advance NC alternatives along maturity path
  - Task II: Demonstrate and validate mature alternatives
    - Task IIA: Invest in development and maturation of high-payoff alternatives with potential to perform better than current state-of-the art, at a reduced cost, or both
  - Task III: Modify specifications to account for improved test methods and new primers with unique properties like metal-rich, e-coat, etc.

Non-chromate Coatings Engineering Circular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NON-CHROMATE
COATINGS SYSTEMS

NAVAIR

Month XX, 2010

AIR VEHICLE ENGINEERING (AVE) DEPARTMENT
NAVAL AIR SYSTEMS COMMAND

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Risk Analysis for Implementation of Non-Chromate Technology

Probability of Failure for Non-Chromate Technology vs. Chromate*	Impact of Non-Chromate Technology Failure			
	Mishap, Replacement	Reduced Service Life, High Repair Costs	Increased Maintenance Activities	Negligible
High				
Medium				
Low				
Same as Chromate				

* Probability of failure of non-chromate technology based on sufficient laboratory testing, comparison to current chromate technology for a particular application, and AIR-4.3.4 endorsement.

High Risk	Critical Application Areas should be avoided until test data supports lowering risk level. Ex. Critical Safety Items (CSI), susceptible to stress corrosion cracking (SCC), high cost for repair, inaccessible areas, etc. **
Medium Risk	Application Areas that need careful consideration and review based on test data. Ex. outer-mold-line, inner-mold line, faying surfaces, direct to metal, metal-to-composite contact, etc. **
Low Risk	Non-Critical Application Areas suitable for Dem-Val/Implementation based on test data. Ex. composites without metallic contact, fiberglass, low impact - low cost components

** Note: Factors such as platform/component operational environment and inspection intervals must be considered and may justify adjustment to the risk analysis level. Ex. Trainer aircraft operate in a less severe environment than ship based aircraft.

Summary

- **Alternatives available for most applications- authorization and transition underway in many areas**
- **Implementation of qualified NC primers on low risk applications/aircraft underway**
- **Field testing of qualified NC primers/coating systems on higher risk applications and aircraft underway with more to come**
- **A new Engineering Circular documents NAVAIR Materials Engineering Division policy for NC Coating Systems and contain information on:**
  - State-of-the-art products & processes
  - Transition drivers
  - Testing requirements
  - Demonstration and validation requirements
  - Transition approach
  - Risk analysis
  - Implementation recommendations